Novel photochromic ink based on plasmon resonance of silver nanoparticles

The counterfeit and pirated goods are worth about half a trillion dollars a year, as reported by the Organisation for Economic Co-operation and Development (OECD) and have huge economic and social impacts [1].

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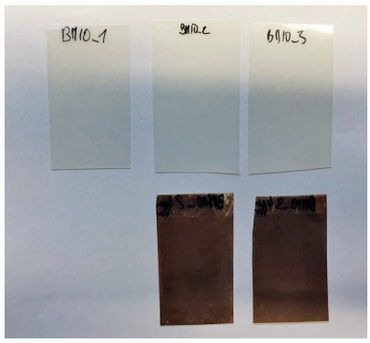
In this context, the research for new, innovative brand protection products (also named anti-counterfeiting) is an important and promising sector in which Switzerland is one of the world leaders.

Purpose

Thus the purpose of this master project was to develop an anti-counterfeiting multilayer system based on Surface Plasmon Resonance (SPR) of silver (Ag) nanoparticles (NPs). The active part of this system is a multicolor photochromic ink which reversibly and rapidly (seconds, minutes) change its color under specific external stimuli e.g. UV monochromatic light.

Development

We developed a system which consists of three superimposed inks. The first ink contains TiO_2 NPs and is deposited by screen-printing, then sintered to obtain a porous media. The second contains a silver salt as a precursor for the formation of Ag NPs and is spin-coated. Eventually, a protective layer made of a UV curable varnish is deposited by inkjet printing on the top of the Ag-TiO_2 film.
The TiO_2 containing ink was formulated based on the "brick and mortar" strategy developed by J.M. Szeifert et al. [2] and screen-printed on a PET-primed substrate (Fig.1). After sintering, the film presented a strong adhesion to the substrate, with a good resistivity to scratching. In addition, well-dispersed TiO_2 NPs were obtained leading to an homogeneous layer as demonstrated by SEM measurements (Fig. 2).



Source: Laurane Schaerer

Figure 1: TiO_2 porous films (top) and TiO_2-Ag films coated with a protective layer (bottom).

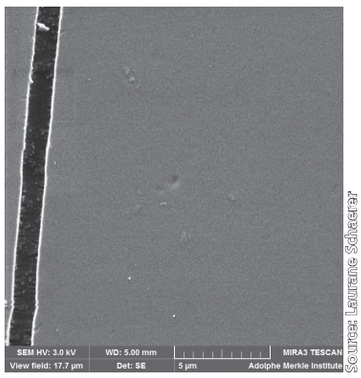


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Figure 2: Image of the TiO_2 layer obtained by scanning electron microscopy.

After deposition of the silver containing ink on the porous TiO_2 film, UV treatment was applied in order to reduce the Ag+ ions present on the surface into Ag(0) NPs. The porous media is acting as a mold for the NPs formation, leading to a variety of different sizes and shapes with a range of variable optical properties. Indeed, due to SPR of silver NPs, the film presented multicolor photochromic properties under monochromatic light treatment. This property was found to be reversible within minutes. The influence of various experimental parameters on the photochromic behavior of the film have been investigated as well.

Conclusion

In conclusion, a proof of concept for an anti-counterfeiting method based on nanoparticles and the SPR effect was successfully realized. However, further investigations have to be performed in order to optimize the photochromic behavior of the ink and to achieve a complete assessment of the color changes in the CIE system.

REFERENCES

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